Greening maintenance

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Environmental sustainability is becoming an important element in evaluating repair strategies, explain **Alan Forster**, **Kate Carter** and **Brit Kayan**

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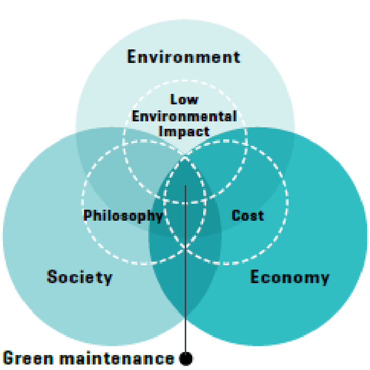
Retention of traditional masonry buildings is important not only from a cultural perspective, but also from an economic standpoint, with 50% of national wealth across Europe being contained within the existing built environment. A lack of regular maintenance significantly devalues these assets due to premature deterioration. But despite its importance, maintenance appears to be poorly regarded by the public and construction industry alike.

Evaluating masonry repairs is almost always set within the parameters of budgetary constraints. But maintenance of historic buildings must also be implemented within a framework based on ethics and principles, including least intervention; like-for-like material replacement; distinguishability; integrity and reversibility. Success is evaluated against these principles. However, a third emerging factor in the process is environmental sustainability.

To evaluate the long-term maintenance requirements of historic buildings in relation to the tripartite approach proposed for 'green' maintenance (see Figure 1), it is necessary to understand the cumulative effect of routine operations in cost, philosophy, and environmental impact. The proposed evaluation framework has the potential to allow selection of the most sustainable solution.

Figure 1
Maintenance parameters



Carbon and energy use

Existing buildings have an important role in reducing carbon emissions and energy consumption, to meet global targets for 2050. Maintenance interventions clearly expend energy, with some leading to higher CO_2 expenditure than others, e.g. the significance of transport. Sandstone from China had more than six times the embodied carbon than the equivalent locally sourced material. This reinforces the influence of regional materials procurement on the total carbon associated with the construction process.

The three most common types of repairs for natural stone masonry are replacement stone, plastic repair, and pinning and consolidation. Replacement stone is considered very durable, with a life expectancy of 100 years. Its defensibility is generally good, enabling the continuity of aesthetic integrity. The energy used in this process is potentially considerable as a result of quarry extraction, processing and transportation.

Plastic repairs (denoting plasticity not the addition of polymers) are a surface repair to deteriorated masonry faces, with a life expectancy of about 30 years. These repairs are highly defensible, because they enable the retention of the maximum amount of existing natural stone. Equally defensible is consolidation and pinning, a stabilisation technique in which nylon or stainless-steel dowels are inserted into holes drilled into delaminating layers or detached sections of masonry, and fixed with modified lime grouts. These repairs do not use a great deal of energy compared to the former interventions, but their life expectancy may be low.

Concept and methodology

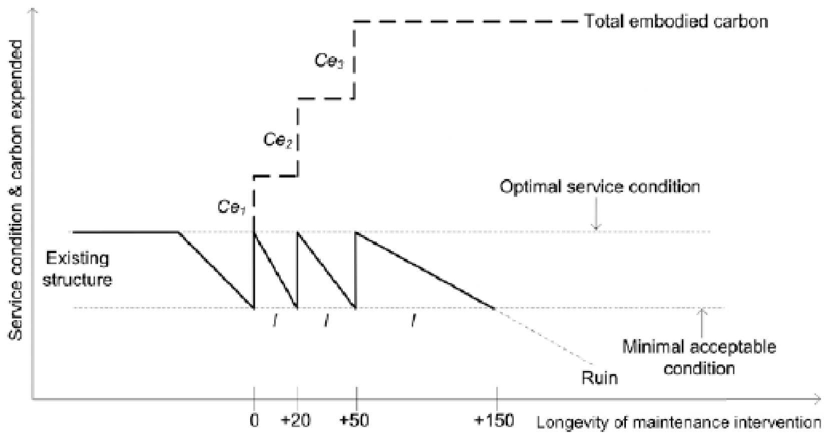
There is clearly a relationship between the number, type and longevity of maintenance, and the embodied energy and CO_2 expended in repairs. A durable repair requiring fewer repeat interventions may incur less energy over the lifespan of the building than a less durable alternative. Although replacing natural stone is a significantly more durable than plastic repair, the energy associated is a great deal higher.

The time between interventions is influenced by many variables, including material durability; degree of exposure; building detailing; quality of repair and specification. Figure 2 illustrates the implications of undertaking maintenance interventions on the service condition of masonry over time. The downward sloping lines signify the steady decline in condition over the life of the repairs. Each maintenance intervention brings the area of masonry back to optimal service condition. It then deteriorates at a rate that depends on the repair type. Intervention is assumed to occur when the minimum acceptable condition is reached. A steep gradient denotes a repair with short life expectancy – such as pinning and consolidation, which can extend the service condition by 20 years. A shallow gradient equates to a durable long-lasting intervention, such as masonry replacement.

If interventions are considered in terms of carbon emissions, it becomes possible to model the whole life cycle of a building in terms of the carbon associated with maintaining it over its life span. Figure 2 overlays the carbon emissions for each maintenance intervention on the service condition graph. The model distinguishes between 'brown' and 'green' maintenance, i.e. interventions of high and low carbon impact. The cumulative effect of 'brown' maintenance increases the total carbon expended far more quickly than 'green'.

In principle, the more frequent the maintenance intervention the higher the embodied CO_2, but various mechanisms may exist to reduce the total CO_2 expended, such as locally sourced materials, using regional companies to undertake the work and selecting alternative repair solutions. A cradle to site approach is required to fully account for CO_2 associated with all aspects of the repair to fully appreciate its environmental impact. On the face of it an intervention with low carbon emissions has less environmental impact. However, the complexity of lifespan and combinations of repair types suggests a whole life cycle approach

Figure 2
Relationship between longevity of repair and total carbon expended



is necessary in determining 'brown' from 'green' maintenance.

If we evaluate the efficacy of repairs in terms of CO_2 expenditure, then the type of repair selected could be tailored to suit environmental aspects rather than longevity alone. This practical approach may be welcomed as society moves toward a low carbon economy, and 'green' procurement selects and prioritises materials with low embodied energy. Additionally, as carbon trading becomes more prevalent, this method of evaluation can be converted into a financial cost.

Philosophical aspects of maintenance are essentially subjective, but are an integral component of achieving 'good conservation'. Retention of existing masonry fabric best satisfies ethical tenets, but it is inevitable that intervention will be required at some stage. Good-quality, durable materials and well executed craft-based techniques offer defensible interventions.

Conclusion

The significant reductions in CO_2 and energy that can be achieved by 'green maintenance' could be of value to decision-makers. This framework facilitates a deeper analysis of the tension between philosophy of repair, set against carbon emissions and cost, making initially difficult decisions easier to defend.

Alan Forster is a lecturer in building conservation, and **Brit Kayan** a former PhD student at Heriot-Watt University. **Kate Carter** is senior lecturer in technology and environment at University of Edinburgh.
a.m.forster@hw.ac.uk

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